
Women in Engineering Education and Services

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ABSTRACT

To achieve a sustainable development in any country, each member of society has to be given equal opportunities, to open out one's inner potential. Actually, the progress of any nation depends mainly upon its human resources, which indeed, is the key behind utilization of all other resources. Women constitute about fifty percent of the population of our country and are indeed, an integral part of our society. All round growth and development of a nation and healthy and harmonious growth of our society would not be possible unless women are brought in to the main stream of national development. Engineering has been associated with development ever since the origin of human civilization and it has always been included as an important agenda in the development discourse of the nation states especially in the context of their infrastructure growth. Women have contributed in all the possible ways to the technical advancement of humanity by holding the same burden as the men did and by accomplishing just as much. They have been resourceful, passionate and certainly creative about their work. This state of art article gives the collective information about the state of Indian women in engineering field.

Key words: *Engineering Education, Career Opportunities, Women*

1 INTRODUCTION

Engineers use mathematics and science along with communications, critical thinking, and management skills to find practical solutions to problems affecting people or society. Engineering knowledge is applied to improve many things, including the quality of the environment, the safety of food products, and the efficient operation of financial systems and so on. The job outlook is very good and the career will not only provide financial security, but also the opportunity to choose among a wide variety of job settings, fields of interest and kinds of tasks. Starting salaries are significantly higher than those of college graduates in other fields. There are many papers which discuss the findings of extensive studies on women engineers in India using data on enrolment in engineering colleges, out-turn job opportunities, career status and other factors.[1-3]

Participation of women in the engineering profession is important from the viewpoint of national development. It is also an important factor in improving the quality of life of women themselves. Despite the fact that the first woman obtained her engineering degree as early as in 1892, their presence in this important profession has traditionally remained low and this has been a matter of concern, the world over. The scenario in India has not been any different. Because of the low presence of women in the engineering profession in India, a broad-based study entitled 'The Participation of Women in Engineering Courses and in the Engineering Profession' was taken up

during 1987- 90 under sponsorship of the Department of Science and Technology (DST), Government of India[2]. The objectives of the study included: assessment of the participation level, analysis of the factors responsible for low participation and study of the job and career status of women engineers in India. The study was planned so as to provide a firm basis for status evaluation and to help in formulation of corrective strategies. The overall framework of the study consisted of collection and analysis of the data on enrolment and out-turns trends (numbers graduating per year), personal/family background, job status, career profiles and career problems of women engineers. Women who had obtained their Bachelor's degree in engineering during the sixteen-year period 1975-1990, in the country, in any branch of specialization, constituted the sample of that study. Out of the total sample size of about 20,000, direct contact could be established with 4678 women engineers and detailed personal, educational and professional data was obtained for 2753 through a structured, specially designed questionnaire. The data and analysis revealed that the number of women taking up engineering courses had increased significantly from only about 1% in 1975 to over 8% in 1990. However, the engineering job market was not open to accepting women as engineering professionals. About 26% (719 out of 2753) reported unemployed. The unemployment problem manifested itself more severely in the states and in the branches having higher enrolment rates and a larger population. Job opportunities for women engineers were limited in terms of sector of employment and the pace of their career growth was slow. The largest numbers were employed in Technical Educational Institutions followed by Government, Civil Services, Public Sector Units and R&D organizations. Non-acceptance of women engineers was particularly evident in the Private Sector Industry. These findings, obviously, were a cause for serious concern. Women's representation in technical field is growing. For example, the percentage of women engineers graduating from IIT Bombay has grown from 1.8% in 1972 to 8% in 2005 [5].

In the present scenario, Information technology, Computer and Biotechnology have received a great deal of interest in modern era of science. It has indeed given new shape to profit making business. One third of Indian populations is E-connected and is leading E life. US president Bill Clinton was very much impressed to see the women living in a tiny village of Rajasthan conducting their dairy business through a network system. Women are creative, innovative, precise, methodical, and highly organized, these god gifted quality helps them in taking crucial research problems which modern biotechnology demands. Now a day's more and more women scientist are entering in the field of modern science of molecular biology and are making a mark in the rapidly growing area of biotechnology [6].

Participation of women in the business world is very small. Is it circumstantial or gender discrimination? Earlier women were opting for a career in teaching, medicine, and pure science where they could pursue their career and also care for the family simultaneously. Truly speaking entrepreneurial spirit has not been wide spread in India. The social background and upbringing are not conducive to the flowering of this spirit among women. It has been seen when women ventures into self employment activities it is generally extension of their homes. When the question of choosing a career as an option arises, generally decision is not made by women scientist and technologist but by their families. Silent revolution is taking place in India. India is the first country in the world, where there is 33% reservation for women at local council level; as

a result nearly 10 Lakhs women are now occupying position as chairperson of panchayat and nagar palikas. But the number of women scientists, engineers and biotechnologists is very small.

Section 2 deals with the men to women ratio in science and engineering. Section 3 deals with the employability status of engineers and career opportunities for women with the background of science and technology.

2 THE MEN TO WOMEN RATIO IN SCIENCE AND ENGINEERING

Thankamma Thankacha[7] of Institute of Applied Manpower Research, New Delhi for example, points out that despite the position of engineering as the second largest profession in the world, at the time of independence India faced acute shortage of engineers. And technicians and engineers were needed mainly to meet the demand even in the basic and traditional industries such as irrigation, power, Public Works, Railways, Road etc. Most often engineering education is viewed in relation with and in the context of national development and demand-supply dynamics in the job market. This is an indicator of the almost complete 'instrumentalist' approach to engineering education both by the society, the state and in consequence, the students.

A survey of the writings in the field on engineering and technology reveals that the growth and development of engineering in India should be placed in different phases. Kumar et al [8] uses the financial source of the funding of the higher educational institutions as the criterion for the categorisation of the phases. They also take into account the privatisation that happened in education sector as an important aspect of the new phase. Even Parikh and Sukhatme [1] state the same with specific reference to the existence of private sector in engineering education and attribute the growth of the engineering sector to the privatisation process. Similarly Thankachan's report mentioned earlier says that India had 6.91 Scientists, Engineers and Technicians (SET) per thousand populations during 1996 and that the scenario changed in the following decade global competition and information technology revolution led to shift in paradigm in engineering practices. Number of engineering institutions has increased from 151 to 1084 (1991-2001) and the percentage of private institutions increased from 56 per cent to 80 per cent during the same period. In 2008, it is estimated that 3.5 lakh engineering degrees, 23,000 engineering Masters degrees and about 1,000 PhDs were awarded in India. Table 1 gives the detail about the number of engineering graduates during 1971-2002. Table 2 shows a substantial increase in the admission and outturn of students across disciplines from the 1990s till 2002. In the last five years, the M Tech/ ME output has increased from about 14000 in 2001 to almost 20000 in 2006 [9].

Though the opportunities for women in science and Engineering (S&E) are continuously improving for future generations, the men to women ratio in S&E fields need some core improvements. One important factor that affects this ratio is that there is significant difference in men's and women's professional lives. Where men and women do not equally share children and household work, it is frequently women who sacrifice their education and career opportunities to the home and family. The question of having families and being serious full-time scientist constitutes a major dilemma for women pursuing careers in S&E. Present employment and promotion criteria and policies do not allow for family responsibilities. The most frequently

reported barrier to women in science and technology is the challenge of combining career and family. Women who give priority to child bearing and child rearing during periods critical to career development and promotion within the current reward systems suffer the career consequences [10].

Table 3 clearly shows that gender ratio is highly skewed in favour of men. Women are not even half of the total number of men who are enrolled in engineering in the last decade. In India, there are 106 males for every 100 females, making the sex ratio 1.06 [11-13]. In contrast, the sex ratio in engineering colleges is 1.96 [14]. This shows that a lower proportion of females make it to engineering courses as compared to males. A 2009 study suggested that the ratio of male to female engineers in USA was as drastic as 4.61. Among different branches, it was found that computer science and electrical engineering disciplines had the least number of females. The men to women ratio (MFR) are shown in Figure 1.

Table 1: Number of students taken admission and passed out at graduate level from 1971-2002 (All India).

Year	Admission	Outturn
1971	18207	18223*
1981	34835	19012
1986	36328	29291
1987	55508	30078
1989	62603	37615
1990	66686	41464
1991	70481	44724
1992	73018	44144
1996	103933	75450**
1997	138450	73936**
1998	122498	69280
1999	185360	72247
2000	197081	74323
2001***	262882**	94639***
2002***	305370	101914

Note: *Number of outturn is larger than the number of admission. No explanation is given for this. Reproduced from India Year Book 2008. However IAMR researchers explain that this must be due to students repeating the course and examination in that particular year.

estimated*Provisional

Source: Table on Select Professional Courses, pp.81, India Year Book 2008 (Made from resources of MHRD, NTMIS, AICTE, Govt of India)

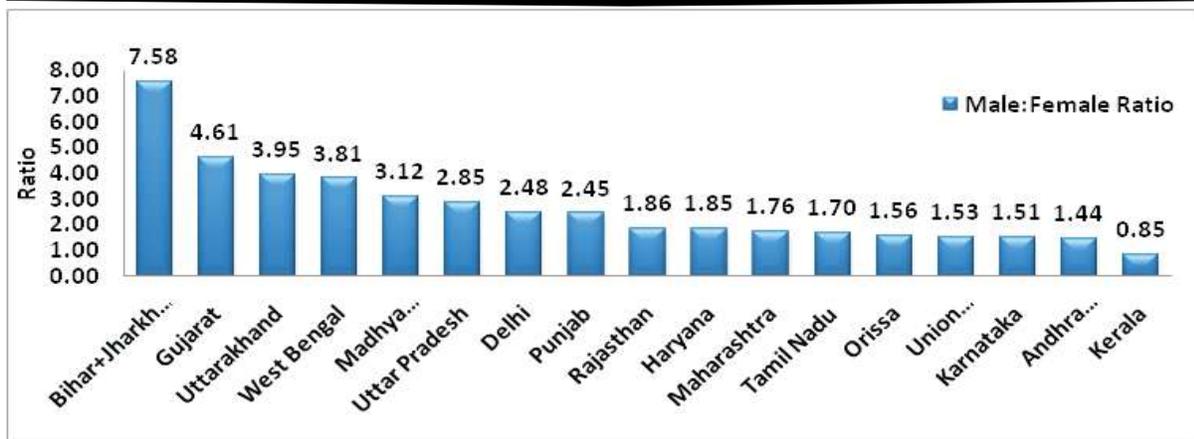


Figure 1: Men to Women Ratio in engineering colleges across states and Union Territories

Source : National Employability report- Engineering graduates- Annual Report 2011

Table 2: Outturn (Discipline wise)(All India) at Graduate Degree Level in Engineering and Technology 1991-2002

Discipline	1991	1992	1996	1997	1998	1999	2000	2001*	2002*
Civil	8514	8147	8875	8998	8787	9119	9336	7422	7471
Mechanical	9257	9538	13582	12757	12877	13800	14191	17674	18132
Electrical	5399	3716	8160	7787	7982	8309	8309	8198	12199
Chemical	1734	1587	2411	2563	2622	2856	2901	3982	3886
Electronics and	6746	7322	18543	18758	18942	13500	13610	13485	18639
Metallurgy	497	469	788	965	987	927	928	849	759
Mining	348	536	508	522	537	542	552	509	419
Automobile	154	207	336	265	281	286	304	286	314
Aeronautical	58	75	102	113	117	90	90	132	127
Agriculture	202	164	359	295	306	265	265	426	337
Production	1112	1032	2132	2086	2092	2173	2173	2414	2706
Sugar	15	15	128	52	56	56	56	24	97
Oil tech	45	46	57	38	39	39	39	54	31
Textile	459	414	581	657	745	804	826	822	921
Architecture	815	743	1391	1379	1373	1597	1650	1672	1788
Food Tech	29	43	85	94	97	111	111	146	600
Instrumentation	863	845	1924	1987	2080	2040	2142	2004	1727
Ceramics	62	60	89	74	68	73	78	315	44
Leather	43	45	61	49	49	69	69	121	124
Others	8372	9139	15538	14497	15173	15591	16693	34104	31593
Total	44724	44141	75450	73936	75210	72247	74323	94639	101914

Source: NTMIS, AICTE, Govt of India.

Table 3: Comparative Figures of Men and Women Enrolled at the Graduate Level Engineering (All-India)

Graduates	Year of Enrolment			
	1981	1986	2001	2011
	Ratio (M:W)	Ratio (M:W)	Ratio (M:W)	Ratio (M:W)
	01:0.04	01:0.08	01:0.28	01:0.51

Source : Table no. 2.1.9, Enrolment in Eng. / Technology /Architecture by Level Page no 65 Manpower Profile 2008.(Source: MHRD and UGC) and National Employability report- Engineering graduates- Annual Report 2011

The MFRs for Jammu and Kashmir, Himachal Pradesh and North Eastern states have not been included due to small sample size. Their ratios are 9.88, 5.42 and 4.58 respectively. It may be observed that the southern states have a more balanced gender ratio than their northern counterparts. This is in line with the population gender ratios across the nation, where northern India has higher male- female ratio than southern India. Figure 1 shows that Kerala has more number of female engineers (Male population of Kerala is less than that of female population). A regional comparison is shown in Figure 2. Delhi, Haryana, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Madhya Pradesh, Panjab, Uttar Pradesh and Uttarakhand form the North zone, Assam, Chhattisgarh, Meghalaya, Orissa, Tripura and West Bengal form the East zone. Gujarat, Maharashtra, Rajasthan and Goa form the West zone. Andhra Pradesh, Karnataka, Kerala and Tamilnadu form the South zone.



Figure 2: Men to Women Ratio in engineering colleges across zones

Source : National Employability report- Engineering graduates- Annual Report 2011

3 EMPLOYABILITY

Engineers are absorbed in many different job profiles and sectors in the industry. Aspiring minds released the national Employability report for technical engineers in 2011. According to that

report; the major sectors employing engineers in large numbers were identified and studied to determine the percentage of employable engineers across the Nation. Figure 3 shows the employability of engineering graduates in different sectors.



Figure 3: Employability of Engineering Graduates in different sectors

Source : National Employability report- Engineering graduates- Annual Report 2011

3.1 Employability by Gender

Aspiring minds analysis shows that employability for males females is almost equal, with the maximum difference being a single percentage point for IT Services and KPO. The employability of males vs. Females is depicted in Figure 4.

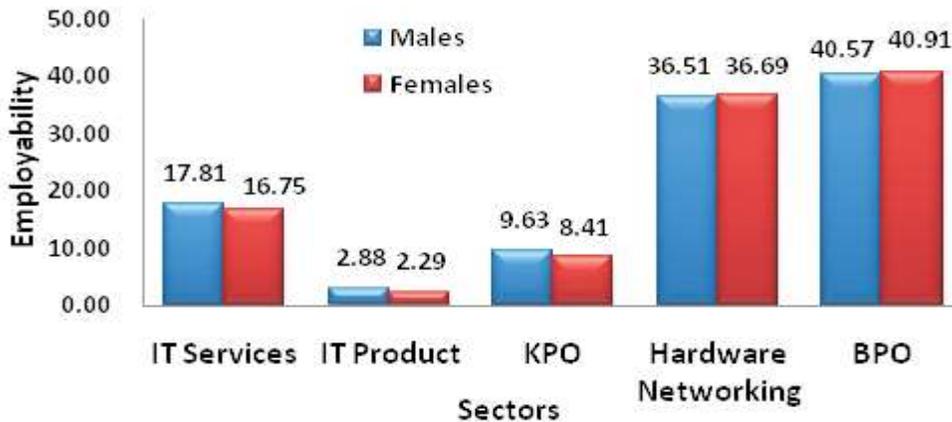


Figure 4: Employability – Males vs. Females

Source : National Employability report- Engineering graduates- Annual Report 2011

The slight difference in the employability of males vs. Females is majorly due to the difference in Quantitative Ability scores based on the AMCAT(Aspiring Minds Computer Adaptive Test). Figure 5 gives the detail about Average AMCAT Scores for engineers.

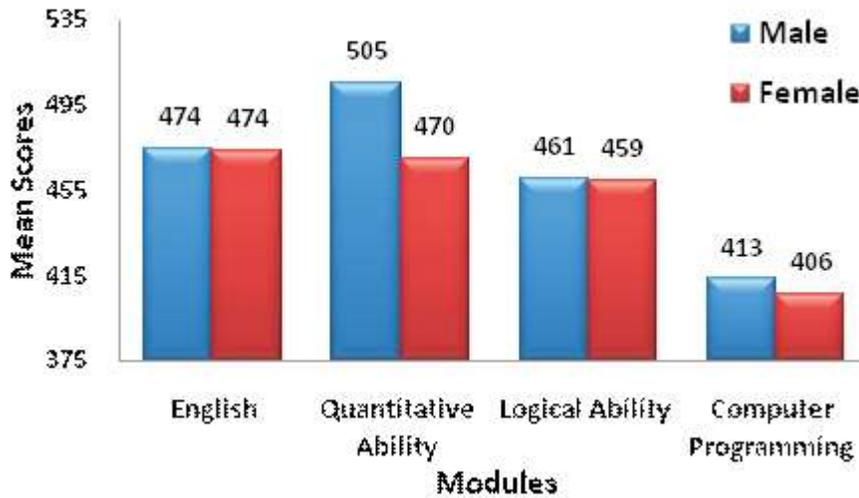


Figure 5: Average AMCAT Score – Males vs. Females

Source : National Employability report- Engineering graduates- Annual Report 2011

In spite of the equal employability of males vs. females, the ratio of males-females in software industry is not same as that in campuses. Industry Statistics in 2009 showed an MFR of 2.33 for IT services. This is higher in comparison to the ratio found in engineering campuses. This shows that fewer proportion of female engineers are employed in the IT industry as compared to males.

3.2 Career Opportunity for women

In the last quarter of the 20th century, Indian women have made the best of existing opportunities by getting into hitherto "manly" professions - be it scientific / technical fields or motor mechanics and locomotive drivers. Women's literacy has climbed to 65.46% from that in 1947. The present day scenario presents a variety of careers for women with a science or technology background. These opportunities can be classified under broad categories namely [15]:

3.2.1 Business or Entrepreneurship

While finding women in business has become common, many technical fields require extensive infrastructure and investments and are viable mainly for large business houses and the government. Professionals like doctors who run their own dispensaries and hospitals, civil engineers, architects etc are some of the well known business persons. Also women in diary field and food processing industry have been running successful business over the years.

3.2.2 Research and Education Institutions

A major work in the field of science and technology is carried out in educational institutions through creating awareness about the need for science education among girls. The number of women in teaching and education professions has traditionally remained high but more

opportunities are available in the field of science education with the increasing number of educational institutions and colleges across the country.

Scientific research in India is carried out under the auspices of the Central Government, the state government and various public and private sector organisations, including Industry. A number of new agencies and departments such as the department of Environment, Ocean development, Non-conventional energy sources, Biotechnology etc., have been set up to deal with newly emerging areas of knowledge. There is urgent need for research scientists in the ever expanding technical fields such as Materials technology, Energy sources, Communications, Manufacturing, Healthcare services, Agriculture sciences, Environmental sciences, Marine sciences, Mathematical modeling, Computer Simulation, Supercomputers, Superconductivity, Geosciences, Microbiology, Ecology, New construction materials, Defence related technologies, Space research, Nuclear research and so on and so forth.

Such research opportunities are expanding in the country as the need for self reliance in high-tech fields is becoming increasingly crucial for sustained development of the country. These options are mainly available for women and men with minimum of graduation in the corresponding fields thus emphasising the need for science education and higher studies too. Dr. Kalpana Chawla, an Indian or Indian American, became the first Indian woman to go into the space on November 19, 1997 on a 16-day mission on NASA's Columbia shuttle as a Mission specialist, to study the outer atmosphere of Sun. Indian space research encompasses the Indian Space Research Organisation ISRO, the Department of Space, and several other organisations that provide various opportunities for research and developmental activities.

3.2.3 Careers in Private / Governmental agencies and Industries

Many exciting careers in science and engineering are available in the present day job market for women. Traditional career opportunities for women included fields such as Medicine, Nursing, Food science etc., but with the widening horizon of science and technology the career opportunities for women have also expanded considerably. Some such fields can be classified under the following heads:

Information technology (IT)

The IT boom as it is called is one of the recent fields that provide extensive scope for employment under its various branches. Though it is restricted mostly to urban and a few rural areas at present, with the necessary impetus from the government it will not be long before this field provides maximum career opportunities and to

Manufacturing and Engineering

This field employs most of our engineers and new trends in computers, lasers, fibre optics and robotics have resulted in Computer Aided Design (CAD) of engineering products etc. Though many of these opportunities were restricted to men in the past, several women engineers have made successful careers also. Many engineering core areas like Civil, metallurgy and Electrical engineering streams also have good female representation of late.

Health Care industry

This industry encompasses in addition to professional like doctors and Nurses, the clinical technology services like testing facilities, Instrumentation laboratory, Herbal and pharmaceutical products, Cosmetics and perfume industry. Most of these opportunities need an educational background in chemical or biological sciences.

3.2.4 Environmental sciences, Agriculture sciences & Biotechnology

These fields though being specialised areas will increasingly provide opportunities with the growing need for pollution studies and development of pollution control and monitoring methods, the need for development of alternate fuel and energy sources. Agriculture and biotechnology fields are growing very rapidly and opportunities for microbiology students show an upward trend.

3.2.5 Materials Technology

Materials are now being recognised as one of the basic resources of mankind, ranking along with living space, food energy and human knowledge. Materials today figure extensively as an enabling parameter in nearly every system associated with modern technologies in a wide spectrum of sectors like aerospace, power generation, microelectronics, bioengineering etc. Graduates in Chemical, physical and materials sciences and higher have opportunities in these fields.

3.2.6 Communication

Telecommunication is essential to our national development and is indeed a resource for tomorrow. With this emphasis on development the options available also are ever increasing.

3.2.7 Aviation & Aerospace industry

Women have been involved in aviation since its earliest days. From E. Lillian Todd, who designed and built aircraft in 1906 to India's first woman pilot Usha Sundaram, women have assumed a variety of roles in the industry. At the close of the 20th century, Astronaut Eileen Collins became the first female Space Shuttle Commander. During the last two decades, the number of women involved in the aviation industry has steadily increased and women can be found in nearly every aviation occupation today. However, the numbers are small by comparison. Women pilots, for example, represent only six percent of the total pilot population. Similar trend of women to men ratios exist in all the above-mentioned fields where very few women rise to decision making positions.

4. CONCLUSIONS

This paper gives the information regarding the engineering graduates in various years, Men to women ratio in engineering colleges and in employability sectors, and the career opportunity for women. The strength of women engineering graduates are less compared with men strength due to the following reasons.

- Women have more family responsibility than men.
- Lack of interest
- Lack of role model, mentor and faculty guidance
- Lack of financial assistance

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